National trends in soil organic matter management

The amount of cropland managed using methods that improve soil organic matter increased by 46 million acres between 1982 and 1997 (figure 6). An additional 48 million acres, formerly with degrading organic matter trends, were taken out of production. Organic matter levels can be improved without taking land out of agricultural production.

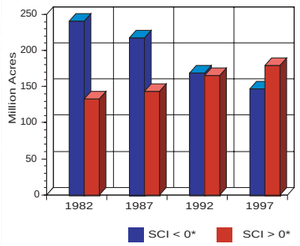

Figure 6: **Trends in soil organic matter management.**

* A positive SCI indicates a cropping system that, if continued, is likely to result in increasing levels of soil organic matter.

What can you do?

Go beyond T–Manage for C. Focus on management practices that build soil carbon and enhance soil function across the landscape. Practice standards important to organic matter management include:

- Conservation Crop Rotation (328)
- Cover Crop (340)
- Residue Management–Mulch Till, No Till, Strip Till, Ridge Till (329A-C)
- Prescribed Grazing (528) when used to improve the health and vigor of pasture plant communities and to improve soil condition.

In addition, appropriate irrigation technology may be important to increasing plant vigor and biomass production.

Expect a transition period and learning curve associated with management changes. Soil biological and physical properties will improve before increased soil organic matter is noticeable.

Avoid single-bullet solutions. No single practice works alone to enhance soil function, and no single set of practices works everywhere. Aim to improve soil organic matter and soil function, rather than to implement a particular set of practices.

Well-managed, continuous no till may be the most cost effective practice in many places, but even no till may not stand alone. No till should be combined with compaction prevention; a diverse, high-biomass rotation; and other locally relevant practices. In some areas, such as on wet and clayey soils, strip tillage or other variations are preferable.

Protect the investment. In many parts of the country, every tillage event can reduce soil organic matter. Occasional tillage can destroy all of the organic matter gained during several years of no till.

For more information about soil quality and soil organic matter, visit the NRCS Soil Quality Web site at http://soils.usda.gov/sqi.

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The Natural Resources Conservation Service provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment.

August 2003

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

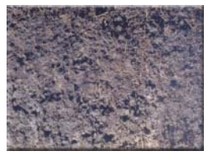
Managing Soil Organic Matter

The Key to Air and Water Quality

Management

Reduced tillage, Cover crops, Rotational grazing, High biomass rotations

Soil quality



Soil organic matter, Soil structure, Soil organisms, Water holding capacity, Infiltration

Air quality, Water quality, Productivity

Fewer pollutants, Less dust, Less sediment, Drought and disease resistance

Erosion control is not enough

Soil conservation policy in the United States stems from the devastating erosion events of the 1920s and '30s. Out of concern for preserving agricultural productivity came the concept of tolerable soil loss and the creation of the T factor–the maximum annual soil loss that can occur on a particular soil while sustaining long-term agricultural productivity. Conservationists focused on reducing soil loss to T by applying practices, such as terraces, contour strips, grassed waterways, and residue management.

By the end of the century, concerns about air and water quality became as important as concerns about agricultural productivity. To address these environmental goals and maintain the land's productive potential, we must now go beyond erosion control and manage for soil quality. How soil functions on every inch of a farm–not just in buffers or waterways–affects erosion rates, agricultural productivity, air quality, and water quality. The most practical way to enhance soil quality today is to promote better management of soil organic matter or carbon. In short, we should go beyond T and manage for C (carbon).

Why focus on soil organic matter?

Many soil properties impact soil quality, but organic matter deserves special attention. It affects several critical soil functions, can be manipulated by land management practices, and is important in most agricultural settings across the country. Because organic matter enhances water and nutrient holding capacity and improves soil structure, managing for soil carbon can enhance productivity and environmental quality, and can reduce the severity and costs of natural phenomena, such as drought, flood, and disease. In addition, increasing soil organic matter levels can reduce atmospheric CO_2 levels that contribute to climate change.

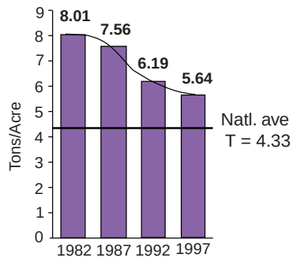


Figure 2: **National annual soil loss.**

The pace of erosion control has slowed as we approach the goal of managing to T. Annually, 1.8 billion tons of soil are still lost from cropland, and 120 million acres of cropland are eroding at a rate greater than T.

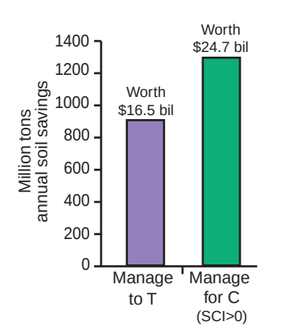


Figure 3: **Managing for soil organic matter can save more soil.**

If all cropland were managed to T, annual soil loss would decline by 0.85 billion tons. If all cropland were managed for C (SCI>0*), soil loss would decline by 1.29 billion tons. Thus, conservation efforts could save an additional $8.2 billion worth of soil annually by managing for C instead of managing to T. Reaching this higher standard is possible by focusing on different conservation tools and benefits.

Go beyond T– Manage for C

The goal of reducing soil erosion to T (tolerable soil loss rates) generated remarkable improvements in the nation's natural resources (figure 2). We can achieve a new level of soil conservation by focusing on building soil organic matter or soil carbon (C).

- By emphasizing organic matter management technology, soil loss can be reduced on those lands that still suffer excessive erosion.
- Even moderate erosion rates can harm air quality, water quality, and wildlife habitat. Improving soil organic matter levels can further stabilize soil within fields and protect environmental quality (figure 3).
- Keeping soil in place is only the beginning of soil conservation. Soil also has to function well. It must hold nitrogen, phosphorus, and pesticides in place and keep them out of surface water. Soil must deliver nutrients and water to plants as they need them. Soil should minimize the effects of floods and droughts. Organic matter helps soil perform all these functions.

What does this mean for conservation?

Managing for C means using well-known technology in a new way. By addressing conservation issues from the perspective of soil organic matter instead of erosion, we will focus on enhancing the soil as opposed to managing for tolerable degradation. We will exploit the full potential of cover crops, crop rotations, and reduced tillage to address conservation concerns. Moreover, managing for C provides additional on-site benefits and incentives for the landowner, creating greater motivation for the person making the ultimate decisions about managing the Nation's natural resources.

Keeping soil in place is only the beginning of soil conservation. Soil also has to function well.

*What is SCI? The Soil Conditioning Index (SCI) predicts the effect of cropping systems on soil organic matter levels. A positive SCI indicates a cropping system that, if continued, is likely to result in increasing levels of soil organic matter. More information about the SCI is at http://soils.usda.gov/sqi.

How does organic matter work?

Once a land manager begins working towards enhancing soil organic matter, a series of soil changes and environmental benefits follow (figure 4). The rate and degree of these changes and the best suite of practices needed to achieve results vary with soil and climate. Initially, managing for greater soil organic matter may require higher pesticide, herbicide, or nutrient applications. In time, productivity and environmental quality will be enhanced.

Apply practices that enhance soil organic matter

- **Diverse, high biomass crop rotations**
- **Cover crops**
- **Reduced tillage**
- **Rotational grazing**

Organic matter dynamics change

- **Increased surface residue forms a physical barrier to wind and water erosion.**
- **Higher residue rotations and cover crops contribute more organic matter and nutrients to the soil.**
- **Less soil disturbance means lower organic matter losses.**

Soil properties change

- **Surface structure becomes more stable and less prone to crusting and erosion.**
- **Water infiltration increases and runoff decreases when soil structure improves.**
- **Soil organic matter holds 10 to 1,000 times more water and nutrients than the same amount of soil minerals.**
- **Beneficial soil organisms become more numerous and active with diverse crop rotations and higher organic matter levels.**

Air quality, water quality, and agricultural productivity improve

- **Dust, allergens, and pathogens in the air immediately decline.**
- **Sediment and nutrient loads decline in surface water as soon as soil aggregation increases and runoff decreases.**
- **Ground and surface water quality improve because better structure, infiltration, and biological activity make soil a more effective filter.**
- **Crops are better able to withstand drought when infiltration and water holding capacity increase.**
- **Organic matter may bind pesticides, making them less active. Soils managed for organic matter may suppress disease organisms, which could reduce pesticide needs.**
- **Crop health and vigor increase when soil biological activity and diversity increase.**
- **Wildlife habitat improves when residue management improves.**

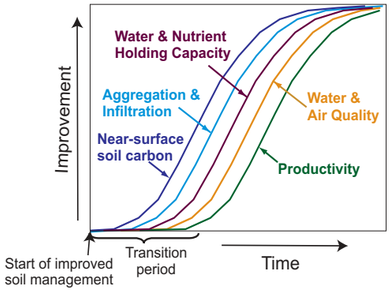


Figure 4: **Clean air and water start with soil organic matter.**

What is topsoil worth?
Organic matter management is cost effective because it can prevent erosion and help remedy the effects of past erosion. Here are examples of how to put a dollar value on soil.

	Cost/ton
Cost by the bag	$40 - $80
Cost by the truckload	$15
Cost to replace soil functions, and remedy off-site damage (figure 5)	$19*
Cost of erosion to downstream navigation	$0 - $5
Cost to human health	$3
Cost to return soil to its original, noneroded condition	Priceless

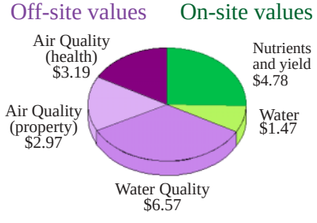


Figure 5: **Components of the value of a ton of topsoil worth $19*.**

*Data are adjusted to 1997 dollars. For more detail see: NRCS. (draft). Soil Quality-Agronomy Technical Note. The economic value of soil quality. http://soils.usda.gov/sqi